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CLINICAL STUDIES

Embolic Potential of Left Ventricular Thrombus After Myocardial Infarction: A Two-Dimensional Echocardiographic Study of 119 Patients

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Left ventricular thrombus complicating myocardial infarction was diagnosed by two-dimensional echocardiography in 119 patients. The infarct site was anterior in 98 patients and inferior in 11. Systemic embolism occurred in 26 patients (stroke in 18, lower limb embolism in 7 and mesenteric embolism in 1). A protruding configuration of the thrombus was more common in the patients with embolism than in those without (23 [88%] of 26 versus 17 [18%] of 93) ($p < 0.01$). Free mobility of the thrombus was found in 15 (58%) of 26 and 3 (3%) of 93 cases, respectively ($p < 0.01$). In predicting embolism, protruding thrombus configuration had a sensitivity of 88% and a specificity of 82%, and positive and negative predictive accuracy was 57 and 96%, respectively. For free mobility of the thrombus, sensitivity was 58%, specificity 97%, positive predictive accuracy 85% and negative predictive accuracy 89%.

In the 46 patients whose echocardiogram was obtained during the hospital admission for the index infarct, repeat echocardiograms were obtained during oral anticoagulant therapy. Twelve of these 46 patients had embolism and 2 of the 12 died. In seven of these patients, full dose oral anticoagulant therapy had been given before embolism occurred and in five it was started after an embolic event. The thrombus decreased in size or disappeared in six patients; in four the thrombus showed no change, and in two of these four emboli recurred despite anticoagulation.

It is concluded that two-dimensional echocardiography may help delineate the embolic potential of left ventricular thrombus complicating myocardial infarction and may be of value in weighing the benefits and disadvantages of oral anticoagulant therapy.

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Autopsy findings have shown that left ventricular thrombus is a common complication after acute myocardial infarction (1–5). With the advent of two-dimensional echocardiography, the diagnosis of left ventricular thrombosis can be made in vivo with good sensitivity and specificity (6–8), and much has been learned about the incidence and natural history of left ventricular thrombus in patients surviving the acute episode (9–11). It has become clear that left ventricular thrombus is unusual in patients with an inferior infarct, but common in patients with an anterior infarct, especially in the presence of severe wall motion abnormalities. In the latter group, the incidence of left ventricular thrombus is approximately 30% (9–11).

However, clinically recognized systemic embolism occurs in only a small number of patients with infarction. In three major studies (12–14), the incidence of systemic embolism was low, but a beneficial effect of oral anticoagulant treatment was demonstrated. However, anticoagulation may not be feasible in some patients and may be contraindicated in others. If some echocardiographic features of left ventricular thrombi could identify those most likely to embolize, this would be of help in selecting patients most likely to benefit from anticoagulant treatment.

A few preliminary reports (15–17) suggested that free mobility or a protruding structure of the thrombus might be important in this respect. In this study we examined the

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value of two-dimensional echocardiography for delineating the embolic potential of left ventricular thrombus in more than 100 patients.

Methods

Patients. The clinical course of 119 patients at our two cardiology centers with a two-dimensional echocardiographic diagnosis of left ventricular thrombus complicating myocardial infarction was reviewed. All patients were studied during the period from January 1, 1981 to May 1, 1983. At both institutions ATL Mark 300 and Toshiba SSH 10A and SSH 40 two-dimensional echocardiographic equipment was used.

Diagnostic criteria. Left ventricular thrombus was defined as an echo-dense mass within the left ventricular cavity 1) that was adjacent to asynergic myocardium, 2) that could be distinguished from the endocardium, and 3) that could be visualized in more than one echocardiographic view, preferably from different transducer positions. To this end we used all available acoustic windows. All tape recordings were independently reviewed by two investigators in real time and slow motion in a blinded fashion. In case of discrepancies a consensus was reached.

The thrombus was described as protruding if the thrombus-blood interface showed a curvature that was opposite in sign to the curvature of the adjacent left ventricular wall. In other words, if the free margin of the thrombus was concave (and thus following the curvature of the left ventricular wall) it was considered to be nonprotruding (Fig. 1).

A thrombus was considered freely mobile if the luminal side of the thrombus showed motion independent of that of the adjacent wall, sometimes opposite in direction, sometimes truly erratic. Motion of the thrombus following the wall in dyskinetic areas was therefore not considered free mobility (Fig. 2).

Myocardial infarction was diagnosed by a typical history, development of diagnostic Q waves and a typical rise and fall in creatine kinase-MB isoenzyme. Infarct localization was defined by the criteria of the American Heart Association (18). Anterior, septal and lateral infarcts were grouped as anterior wall infarcts, and, likewise, inferior and posterior infarcts were grouped together as inferior infarcts. Patients with an infarct in whom thrombus was diagnosed during the period of hospital stay (<4 weeks) were grouped as having an acute infarction. All patients with an acute infarction were studied prospectively as part of an ongoing study in the coronary care unit. Patients with infarction in whom thrombus was diagnosed after this 4 week period were considered to have chronic infarction. This part of the study was essentially retrospective.

Statistical analysis. Comparisons between subgroups were performed by Student's *t* test or chi-square testing where appropriate. A probability value of less than 0.05 was considered statistically significant. Sensitivity of a diagnostic criterion was defined as: TP/TP + FN and specificity as: TN/TN + FP, where FN = false negative, FP = false positive, TN = true negative and TP = true positive results. Positive predictive accuracy was calculated as: TP/TP + FP and negative predictive accuracy as: TN/TN + FN.

Figure 1. Two-dimensional echocardiograms. **A**, Example of a protruding type of left ventricular thrombus (**arrowheads**) in an apical two chamber view (Ap2C) from the cardiac apex. **B**, Example of a nonprotruding thrombus (**arrowheads**) in an apical four chamber view (Ap4C). The thrombus is concave toward the left ventricular lumen. LA = left atrium; LV = left ventricle; RA = right atrium; RV = right ventricle.

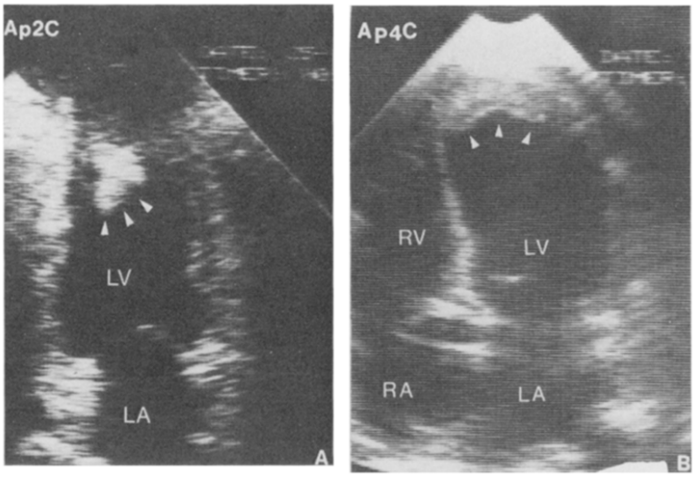
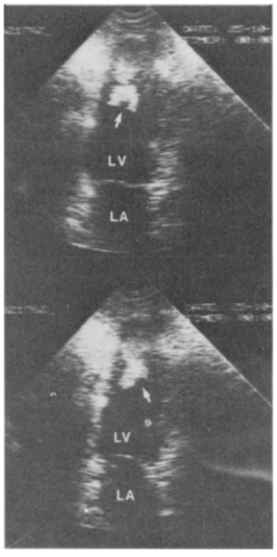


Figure 2. Same case as in Figure 1A. Two still-frames from different time periods in the cardiac cycle illustrating the free mobility of this thrombus (**arrows**). In real time, this thrombus showed erratic motion. Abbreviations as in Figure 1.



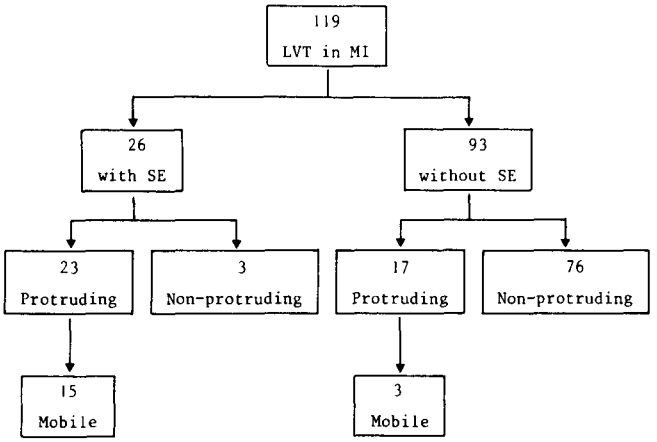


Figure 3. Flow chart showing number of patients with thrombus characteristics in relation to embolization. LVT = left ventricular thrombus; MI = myocardial infarction; SE = systemic embolism.

Results

Of the 119 patients, 46 had acute myocardial infarction. The remaining 73 patients had chronic infarction and were studied 4 to 25 months after infarction. The infarct site was anterior in 108 patients and inferior in 11. Clinically recognized peripheral embolism occurred in 26 patients (21%) of the study group including stroke in 18, lower limb embolism in 7 and mesenteric embolism in 1. Although embolism occurred more frequently in the patients with an acute infarct than in those with a chronic infarct, this difference was not significant: 12 (26%) of 46 versus 14 (19%) of 73 ($p = 0.26$).

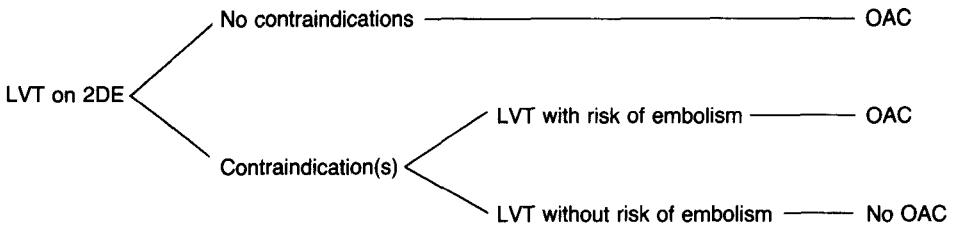
Thrombus characteristics. A protruding type of embolus was seen in 23 (88%) of 26 of the patients with embolism and in 17 (18%) of 93 of those without (Fig. 3); this difference is significant ($p < 0.01$). Free mobility of the thrombus was seen in 15 (58%) of 26 patients in the embolism group compared with 3 (3%) of 93 in the nonembolism group ($p < 0.01$). In all patients with a freely mobile thrombus, the thrombus was also protruding. Eight of the patients in the embolism group had a protruding thrombus without free mobility and the same was true in 14 patients of the nonembolism group. In no case was free mobility observed in a nonprotruding thrombus (Fig. 3). Localization of the thrombus was apical in all but two patients with thrombus in a basal posterior wall aneurysm.

Sensitivity/specificity analysis of protruding thrombus configuration and of free thrombus mobility in identifying thrombi prone to embolization indicated that a protruding thrombus configuration had a greater sensitivity in predicting systemic embolization than did free mobility (23 [88%] of 26 versus 15 [58%] of 26), but was less specific (76 [82%] of 93 versus 90 [97%] of 93). Positive predictive accuracy of a protruding configuration was 23 (57%) of 40 and negative predictive accuracy was 76 (96%) of 79. Positive and negative predictive accuracy of free mobility was 15 (85%) of 18 and 90 (89%) of 101, respectively.

Role of anticoagulant therapy. The effects of oral anticoagulants were investigated in the 46 patients with thrombus complicating an acute infarct. Of these, two were located in a posterior wall aneurysm; systemic embolism occurred in neither of them. Forty-four patients had an anterior infarct with thrombus, and systemic embolism occurred in 12. Seven of these 12 patients were already on full dose oral anticoagulant therapy when embolism occurred. The remaining five were taking subcutaneous heparin but changed to an oral anticoagulant after the embolic event. Two of the 12 patients with embolism died (one developed cardiogenic shock 2 days after sustaining emboli to both legs and another died from mesenteric embolism); in both, the diagnosis of embolism and of left ventricular thrombus were confirmed at autopsy. Repeat echocardiograms were obtained in the 10 survivors of embolism while taking oral anticoagulants at 3 months. In three, the thrombus had disappeared, in another three it had decreased in size and in four there was no change in thrombus size or configuration. A new episode of systemic embolism occurred in two patients despite treatment with an oral anticoagulant; in both patients, thrombus configuration was unchanged.

In the 73 patients with thrombus complicating chronic infarction, the thrombus site was anterior in 64 and inferior in 9. Thirteen and one of these patients, respectively, had systemic embolism. Only 4 patients were receiving an oral anticoagulant at the time of embolism, but all 14 were treated with an anticoagulant after the embolic event and the dem-

Figure 4. Decision tree for assessing indications and contraindications of oral anticoagulation (OAC) if left ventricular thrombus (LVT) has been diagnosed by two-dimensional echocardiography (2DE).



onstration of a left ventricular thrombus as its likely source. In none of the patients did a new embolic episode occur. Follow-up echocardiograms could not be obtained systematically in this group.

Discussion

Left ventricular thrombus can be found frequently at autopsy in patients with myocardial infarction (incidence rates of 14 to 68% have been reported) (1–5). In patients undergoing open heart surgery (mainly aneurysmectomy) after myocardial infarction, a high incidence of left ventricular thrombus also was found, ranging between 16 and 100% of the cases (19) (53% in the largest reported series [20]). Despite this high incidence of thrombus, systemic embolism is relatively uncommon. In three major series (12–14) it occurred in 2.5 to 4.9% of patients not receiving anticoagulant therapy and in 0.7 to 1.1% of those receiving anticoagulant therapy. Because the consequences of an embolus are often disastrous and because the incidence of systemic embolism might be reduced by treatment with oral anticoagulant therapy, recognition of this high-risk group is of paramount importance.

Before the era of two-dimensional echocardiography, an in vivo diagnosis of infarct-related thrombus could be made in a few patients by left ventricular cineangiography. However, this procedure is performed in selected patients, is invasive and has a low sensitivity (approximately 30%) (21). Two-dimensional echocardiography has been shown to have good sensitivity and specificity in the diagnosis of thrombus (6–8). Moreover, it is a noninvasive procedure that can be repeated as needed. Several echocardiographic studies have indicated that thrombus is a frequent sequel to infarction, especially anterior wall infarction with severe wall motion abnormalities.

Thrombus prone to embolization. On the basis of pathologic data (22) and preliminary echocardiographic reports (15–17), it has been suggested that protrusion of the thrombus into the left ventricular cavity (and thus exposure of thrombus to blood flow on several sides) and free mobility of the thrombus (which may indicate friability of the thrombus) might entail an increased risk of embolization. Our study supports this concept. The results showed that thrombus of a protruding type is far more common in patients with embolism than in those without. Free intracavitary mobility of the thrombus was present in more than half of those with embolism and virtually absent in the group without. In other words, a protruding thrombus carries a substantial (but not absolute) risk of systemic embolization. If the thrombus shows free mobility, the risk is even greater.

Although the two criteria employed in the present study may seem subjective, they can be appreciated readily: a thrombus was considered protruding if its luminal edge had a curvature opposite in sign to that of the adjacent left ventricular wall. If the thrombus edge moves with the adjacent wall it is not freely mobile. Free mobility is motion unrelated to that of the wall and often erratic.

Effects of oral anticoagulant therapy. Only the patients with thrombus complicating acute infarction form a prospective group. In patients receiving oral anticoagulant therapy, it was possible for a thrombus to disappear or decrease in size or to stay the same. Because our series was small and not randomized, it is hard to draw any conclusions from it. It is disappointing, however, that of the 12 patients with embolism complicating thrombus in acute infarction, 7 were already receiving oral anticoagulant therapy when embolism occurred, and that in 2, embolism recurred while they were receiving effective oral anticoagulant therapy. In the group with emboli complicating thrombus related to chronic infarcts, follow-up echocardiograms could not be obtained in a systematic fashion. Moreover, this was not a prospective series.

Recommendations for anticoagulant therapy. If left ventricular thrombus is diagnosed on two-dimensional echocardiography, it would seem prudent to administer anticoagulants to all patients if no contraindications exist (12–14). If contraindications exist, the risks of anticoagulant treatment should be weighed against the risks of no treatment. It is here that the two-dimensional echocardiographic features of the thrombus may help in decision-making (Fig. 4). Ultimately, however, the efficacy of oral anticoagulants in preventing systemic embolism or resolving left ventricular thrombus, or both, must be proved in a randomized and possibly blinded (probably multicenter) two-dimensional echocardiographic study.

Conclusions. We believe that left ventricular thrombus complicating myocardial infarction that is prone to embolization can be identified by two-dimensional echocardiography on the basis of a protruding configuration, especially in association with free mobility of the free edge of the thrombus. These features may help in outlining the indications for oral anticoagulant therapy in patients with relative contraindications for such therapy.

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